Climate, Weather and Water Services

Martin Hoerling

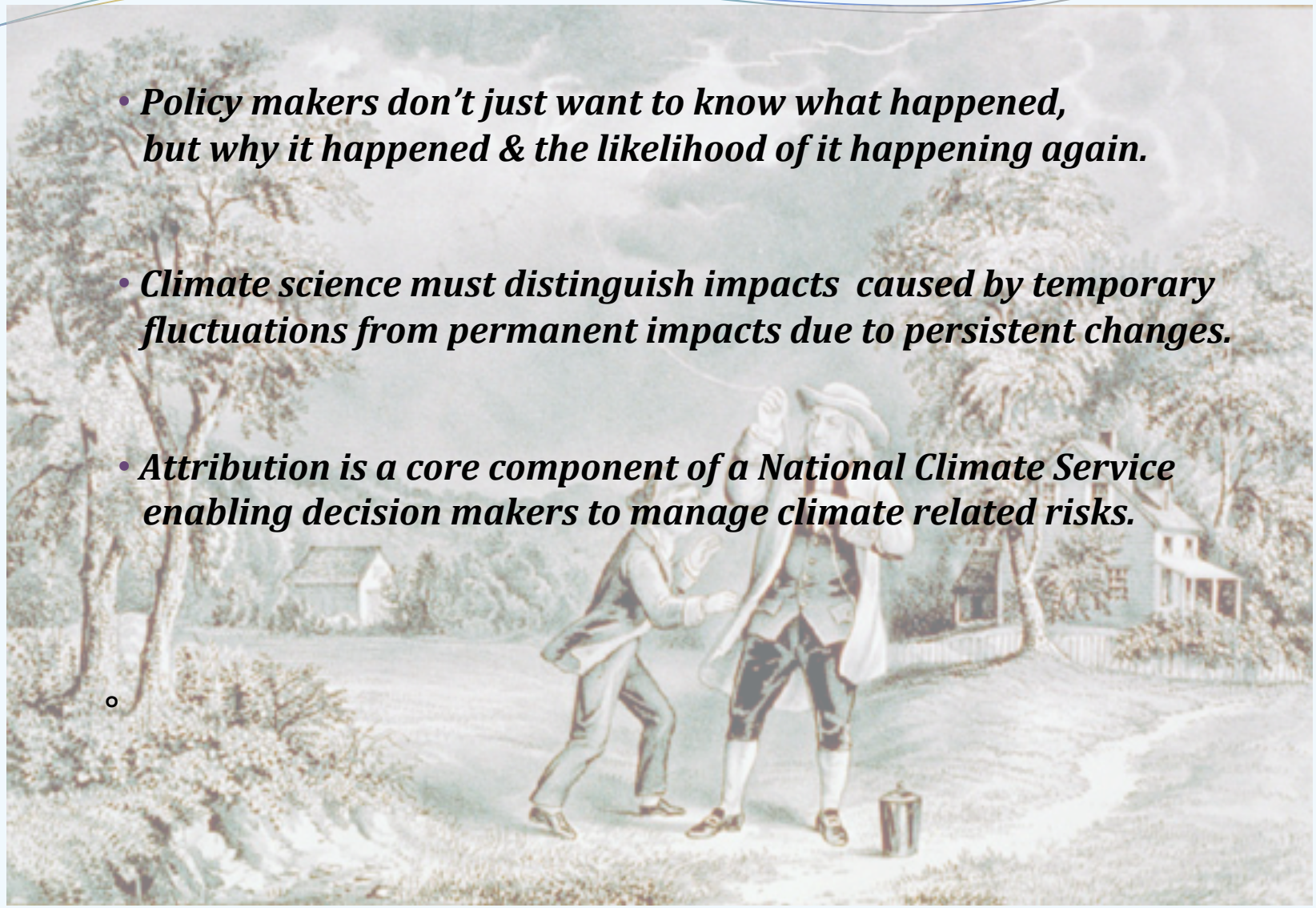
Development of an Attribution Services Capability

What is Attribution?

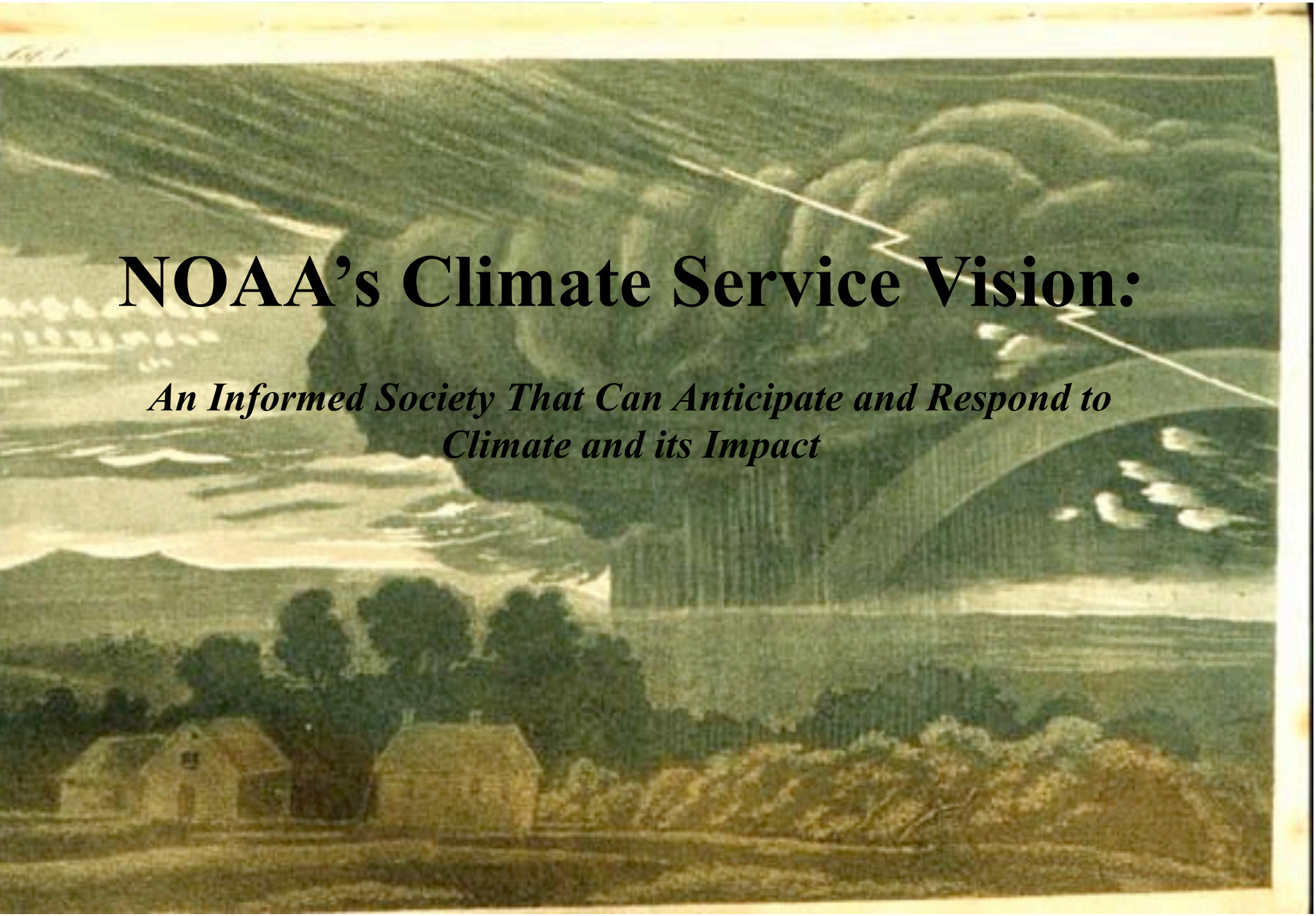
- **Attribution is the *scientific process* of establishing the physical causes or physical explanation for observed climate conditions.**

- **Attribution, by scientifically ascertaining mechanisms responsible for climate conditions, informs predictability and prediction science.**

Why Do Attribution?



- ***Policy makers don't just want to know what happened, but why it happened & the likelihood of it happening again.***
- ***Climate science must distinguish impacts caused by temporary fluctuations from permanent impacts due to persistent changes.***
- ***Attribution is a core component of a National Climate Service enabling decision makers to manage climate related risks.***



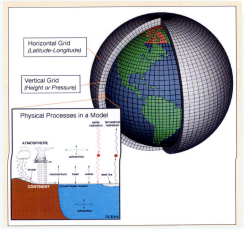
NOAA's Climate Service Vision:

An Informed Society That Can Anticipate and Respond to Climate and its Impact

How Are We Doing Attribution?

- **Attribution is not a "sometime" activity, its *an all-the-time activity***
  Vision is to build a capacity to explain climate conditions all the time, in real time.

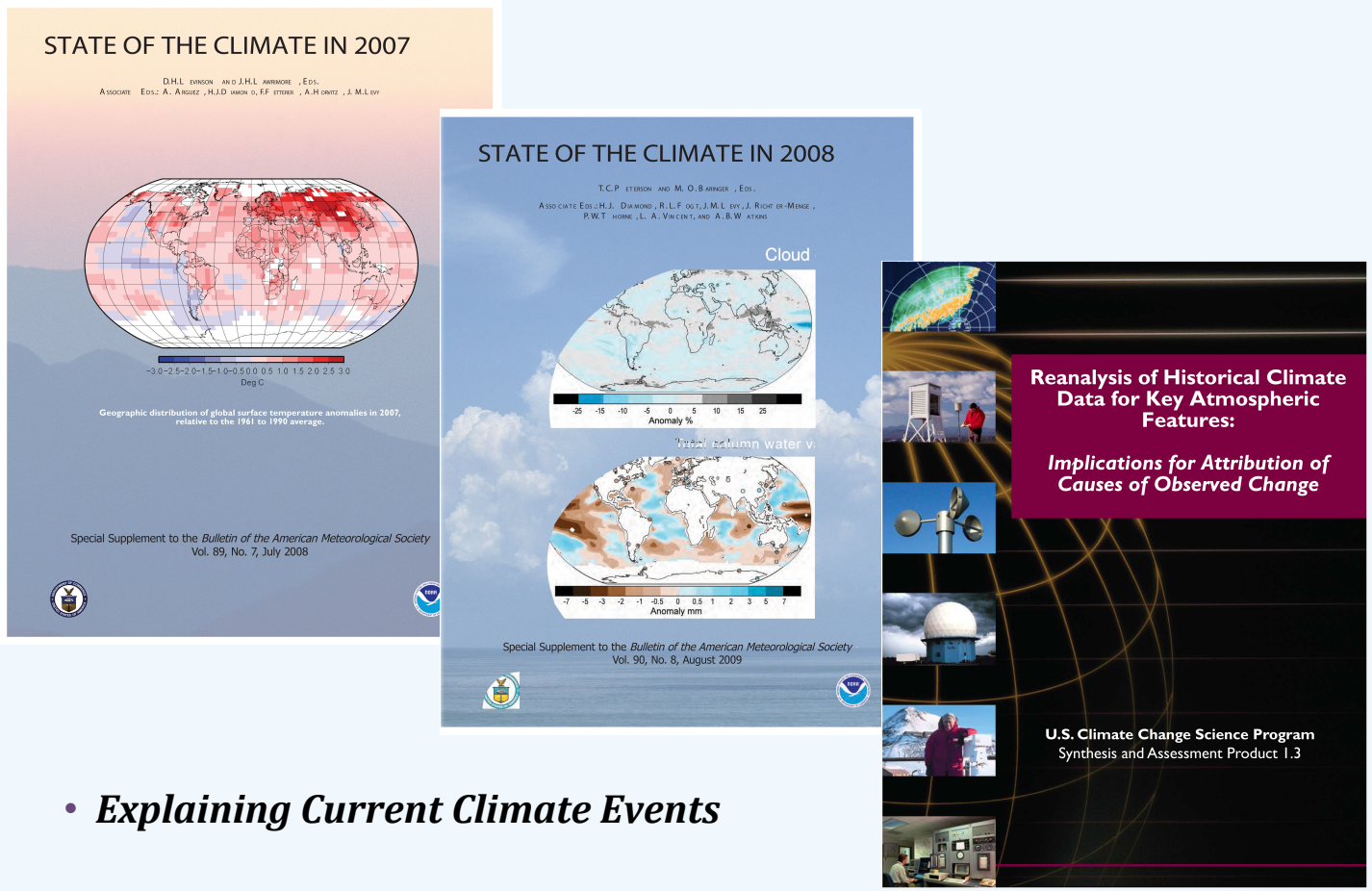
- **Successful attribution is "connecting data" not "collecting data"**
  Successful attribution requires a skilled, integrated Team. NOAA's CSI Team is led by PSD scientists partnering with CPC, NCDC, GFDL.



- **Model experimentation to link climate conditions & forcings**
  Attribution requires repeated and ongoing experimentation. We employ multi-model, large ensemble, multi-forcing simulations with GCMs.

- **We are conducting attribution "opportunistically"**
  Our attribution activity is resource constrained. It therefore is opportunistic rather than comprehensive, and delayed mode rather than real time.

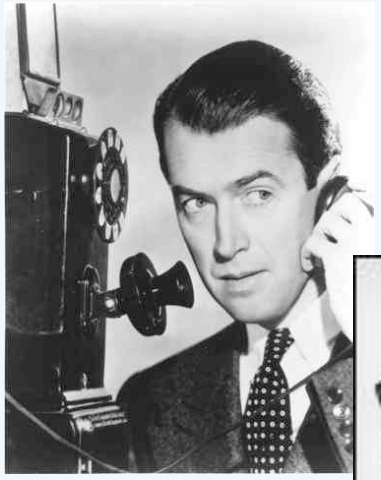
How Are We Communicating Attribution Science?



- ***Explaining Current Climate Events***
- ***Explaining NA Historical Climate Variability***
- ***Articulating a Vision for Climate Attribution***

Monthly Conference Calls

Intense Attribution Periods



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CSI: NOAA Climate Scene Investigators

By Katy Human

Oct 23rd, 2009

Introduction

The Case of the February Tornadoes

The Case of the Midwest Floods

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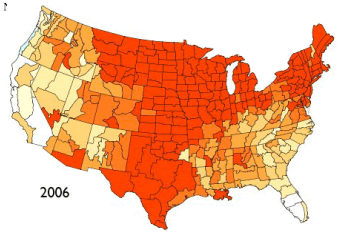
CSI: NOAA Climate Scene Investigators



Marty Hoerling of NOAA's Earth System Research Laboratory.

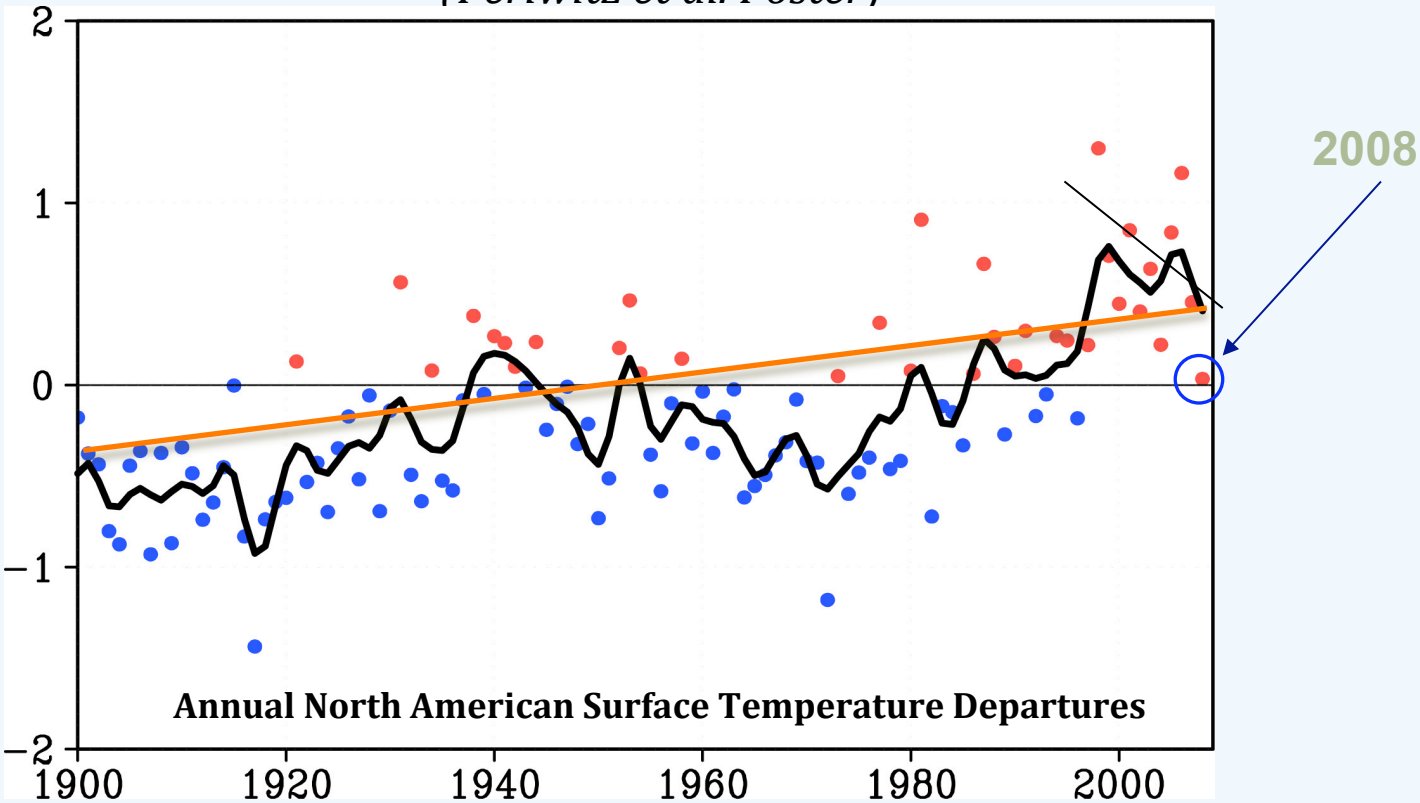
On the television show, CSI, Raymond Langston leads a team of forensic scientists who investigate brutal crimes to figure out who committed them. In NOAA's version of CSI, Marty Hoerling leads a group of climate and weather researchers who investigate killer climate patterns—heat waves, tornadoes, and floods—to figure out what may have triggered them.

http://www.climatewatch.noaa.gov/2009/articles/csi-noaa-climate-scene-investigators Page 1 of 3

Attribution in Action

What is Causing the Variability in North American Temperature?

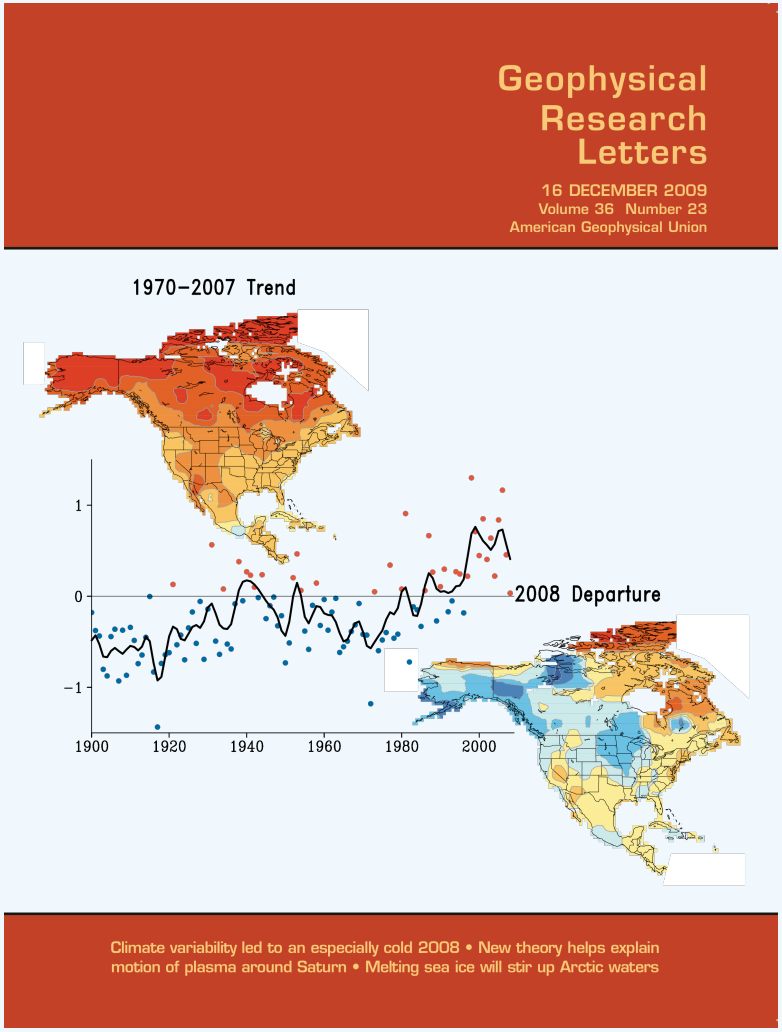
(Perlwitz et al. Poster)



- *"Welcome to the new ice age" (National Post, February 25 2008)*
- *"Global warming skeptics buoyed by record cold" (Telegraph, February 26 2008)*
- *"Skeptics on Human Climate Impact Seize on Cold Spell" (NYTimes, March 2 2008)*

A Strong Bout of Natural Cooling in 2008

(J. Perlwitz, M. Hoerling, J. Eischeid, A. Kumar)



Attribution In Action

How is Anthropogenic Forcing Affecting Colorado River Water Resources?

Past Peak Water in the Southwest

Martin Hoerling – NOAA Earth System Research Laboratory and Jon Eischeid – University of Colorado, CIRES

Nobody relishes being "past peak" anything. Whether it's the prime of our human existence or the prime of Nature's abundance, the notion of having less rather than more is often vehemently denied. But demand growth in the face of production and storage decline has severe consequences, especially when existing uses already consume the available supply.

The lifeblood of the Southwest is the Colorado River, which is increasingly impacted by climate forces not previously experienced. The recent drought prompts concern among water users and water stewards alike, and requires the scientific community to probe whether a sustained threat is rising to our already perilous moisture balance. The consensus of the Intergovernmental Panel on Climate Change (IPCC, 2001) affirms that Earth's atmosphere is accumulating unprecedented quantities of carbon dioxide that are now causing detectable increases in surface air temperature.

Is this ongoing drought an early warning sign of something other than the historical norm, and the gateway to a future climate with more severe drought hazards? What is known about the sensitivity of moisture conditions in the Southwest to a changing climate? To seek answers to these questions, we have undertaken a systematic analysis of a new suite of climate model simulations from the arsenal of tools contributing to the 2007 IPCC Fourth Assessment Report (AR4). What is the news for the Southwest?

Even several of the wetter runs yield increasing drought due to the overwhelming effect of heat-related moisture loss.

A New Drought Study

A common practice in drought monitoring is to derive a meteorological quantity known as the Palmer Drought Severity Index (PDSI; Palmer 1965). The index calculates the cumulative effects of precipitation and temperature on surface moisture balance. Water storage is solely derived from a two-layer soil system, with no explict accounting for deep groundwater or water in manmade surface storage. Drought develops when evapotranspiration exceeds the supply available from precipitation and soil moisture relative to a region's "normal" water balance. The index ranges from -4 (extreme drought) to +4 (extreme moistness).

Reservoir storage is key for assessing water supply during the course of a year in the Southwest, and is not included in a PDSI drought monitor. However, when monitoring drought conditions on annual time scales, streamflow is strongly correlated with annual PDSI. The relationship between the annual virgin flow (the estimated flow of the stream if it were in its natural state and unaffected by the activities of man) at Lees Ferry, Arizona, and the PDSI averaged over the upper Colorado Basin drainage is

$$FLOW = A_0 + (A_1 \times PDSI)$$

for FLOW greater than the estimated basal flow of 3 million acre-feet (maf). Using data from 1895-1989, the linear regression coefficients are

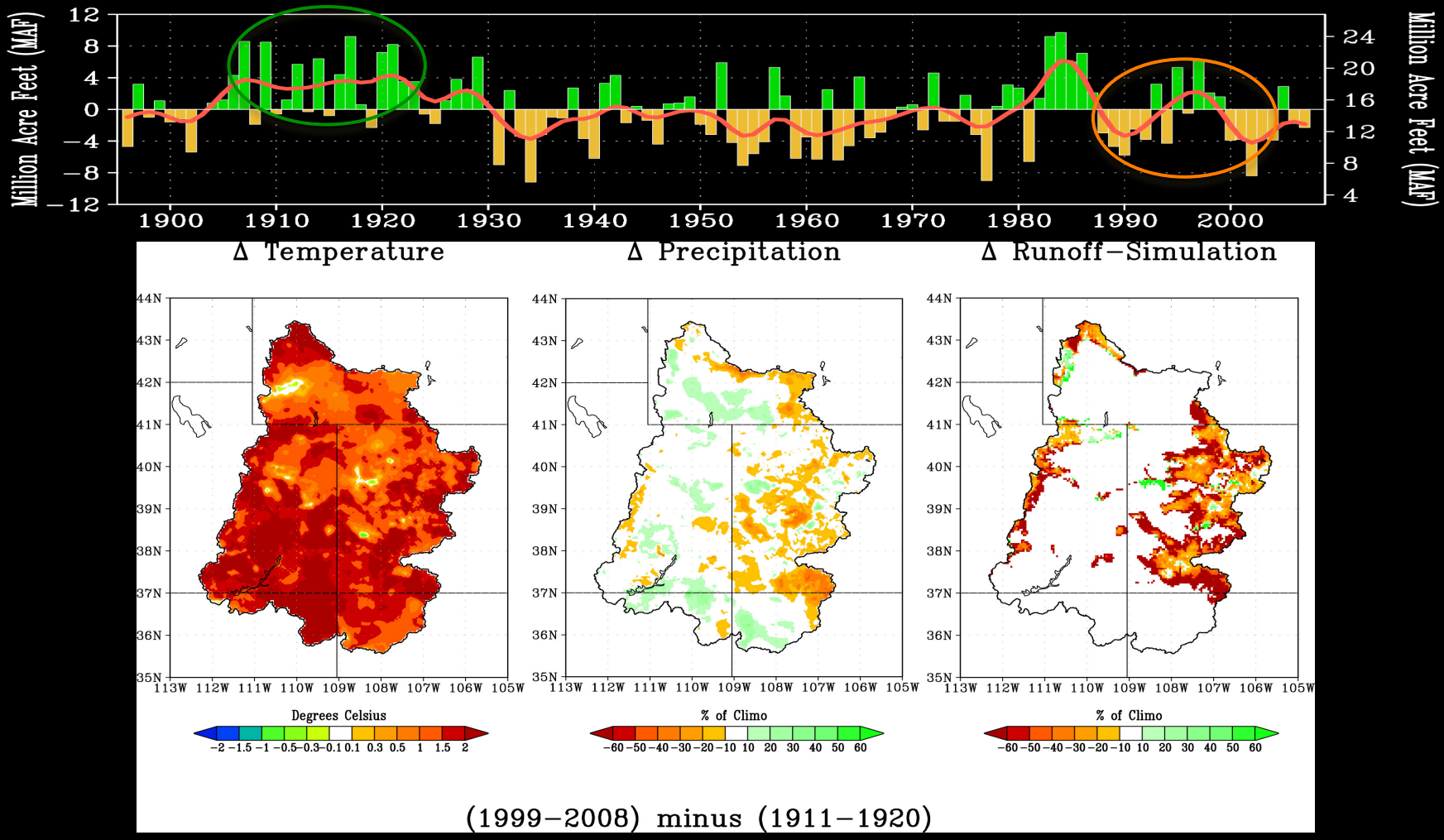
$A_0 = 14.5$ maf, $A_1 = 1.69$ maf.

During the 95-year reference period, annual PDSI explains 63 percent of the annual river flow variations at Lees Ferry.

Post-1989 data offer an independent period to confirm applicability of the above relation for predicting Lees Ferry flow. This period is one of warming temperatures, allowing us to test the prediction equation's fidelity in an environment of climate change. For 1990-2005, PDSI predicts 85 percent of the recent yearly fluctuations of flow at Lees Ferry, including the low flow regime during the recent drought.

To determine the probable hydrologic consequences of future climate change, the above formula was used to downscale

What Has Caused the Decline in Colorado Water Resources?



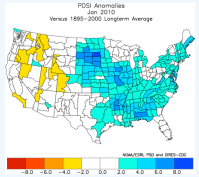
Backup Slides

Attribution in Action

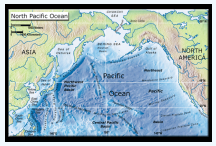
Focus Activities During the past 12-months

- **Assessing Causes for Heavy 2009/10 Precipitation in the Red River Basin**

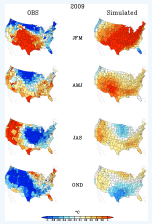
- **Explaining Causes for the 2009/10 Mid-Atlantic Record Snowfall**



- **Assessing Factors Responsible for Current Lack of North American Drought**



- **Determining Climate Impacts of 2009/10 North Pacific Ocean Cooling**



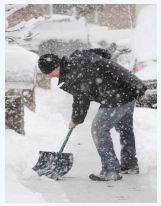
- **Explaining Extreme Seasonality in 2009 U.S. Surface Temperatures**

Attribution in Action

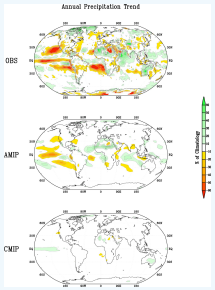
Focus Activities During the past 12-months

- **Determining the Severity of the December 2009 Blocked NAO Event**

- **Determining the Ocean's Role in the Spring 2008 Midwest Floods**



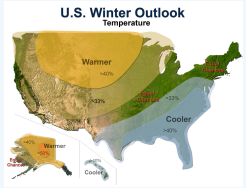
- **Explaining Cold 2008 North American Surface Temperatures**



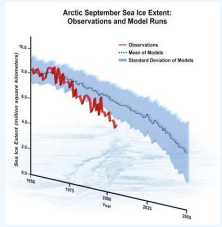
- **Distinguishing Natural vs. Anthropogenic Forcing of Regional Pcpn Trends (1977-06)**

Attribution in Action

Focus Activities During the past 12-months



- **Explaining Success/Failures of Recent NOAA Seasonal Outlooks**



- **Determining the Impact of the 2007 Arctic Sea Ice Loss**

- **Explaining Causes for the 1930s and 1950s U.S. Droughts**